CLAIMS

What is claimed is:

1. An apparatus for perforating a tubular structure, the apparatus comprising:

a housing having a first end defining an inlet, the housing being supportable at a selected position in the tubular structure and defining an operating fluid flow path beginning with the inlet;

a perforating assembly in the housing, the perforating assembly comprising a piercing member supported for movement from a first position within the housing to a second position in which a portion of the piercing member is extendable through the tubular structure, wherein the piercing member comprises a fluid flow path;

wherein the perforating assembly defines a fluid flow path continuous with the operating fluid flow path through the housing and the fluid flow path in the piercing member so that when the piercing member is in the second position a continuous flow path is formed between the inlet of the housing and the portion of the piercing member that this extendable through the tubular structure; and

a control assembly adapted to control movement of the piercing member.

2. The apparatus of claim 1 wherein the first end of the housing is adapted for connection to an elongate conduit extending from one end of the tubular structure so that the conduit is continuous with the inlet of the housing.

3. The apparatus of claim 2 wherein the apparatus further comprises a releasable lock assembly operable by rotation of the elongate conduit between a locked, position in which the elongate conduit is fixed relative to the housing, and an unlocked position, in which the elongate conduit is axially movable relative to the housing.

4. The apparatus of claim 3 further comprising a friction member on the housing sized to frictionally engage the tubular structure as the tool is pushed through the tubular structure.

5. The apparatus of claim 4 wherein the friction member is a bow-spring centralizer.

6. The apparatus of claim 3 wherein the perforating assembly comprises a cylinder, wherein the piercing member is slidably supported in the cylinder, wherein the perforating assembly further comprises a first fluid-driven piston in the cylinder for driving the movement of the piercing member, wherein the apparatus further comprises a pressurized fluid reservoir fluidly connected to the cylinder so that when the reservoir is filled with pressured fluid the fluid can drive the piston, and wherein the control assembly comprises a valve adapted to control the flow of pressurized fluid from the reservoir to the cylinder.

7. The apparatus of claim 6 further comprising a setting/pack-off assembly adapted to secure the apparatus at the selected position in the tubular structure, the setting/pack-off assembly comprising:

a back-up plate sized to engage the tubular structure and movable in a first direction from a retracted position in which the back-up plate does

not engage the tubular structure to an extended position in which the back-up plate engages the tubular structure;

a cylinder supported in the housing;

a fluid-driven piston sealingly slidable within the cylinder and dividing the cylinder into a first chamber and a second chamber;

a stem extending between the back-up plate and piston and;

wherein the first chamber of the cylidner is fluidly connected to the pressurized fluid reservoir to push the piston in the first direction when the reservoir contains pressurized fluid; and

wherein the valve controls the flow of fluid from the fluid reservoir to the cylinder of the setting/pack-off assembly.

8. The apparatus of claim 7 wherein the housing is cylindrical defining a sidewall, wherein the piercing member extends radially through the sidewall, wherein the back-up plate extends radially from the sidewall of the housing and is positioned to move opposi ngly to the piercing member, and wherein the setting/pack-off assembly further comprises a ring-shaped packer on the sidewall opposite the back-up plate.

9. The apparatus of claim 7 wherein the piercing member comprises a base and is movable from the second position to a third position in which the base is extendable through the perforation made by the piercing member to occlude the perforation, wherein first piston of the perforating assembly comprises a recess, wherein the perforating assembly further comprises a second fluid-driven piston slidably receivable in the recess for driving movement of the piercing member from the second

position to the third position, wherein the recess is fluidly connected to the pressurized fluid reservoir so that when the reservoir is filled with pressured fluid the fluid can drive the movement of the second piston, and wherein the valve is adapted to control the flow of fluid from the reservoir to the recess.

10. The apparatus of claim 9 wherein the valve comprises:

a valve body having a tubular sidewall defining a longitudinal throughbore, wherein the sidewall comprises a first inlet fluidly connected to the pressurized fluid reservoir, and a plurality of longitudinally spaced-apart outlets, a first one of the plurality of outlets fluidly connected to the first chamber of the cylinder of the setting/pack-off assembly to drive the piston in the first direction, a second one of the plurality of outlets fluidly connected to the cylinder of the perforating assembly to drive the movement of the first piston, a third one of the plurality of outlets fluidly connected to the cylinder of the perforating assembly to drive the movement of the second piston;

a sleeve sealingly slidable inside the throughbore of the valve body;

wherein the sleeve comprises an outer wall, an inner wall, an annular space therebetween, a fluid inlet in the outer wall in fluid communication with the annular space, and a plurality of outlets in the outer wall in fluid communication with the annular space, each one of the plurality of outlets corresponding to a respective one of the plurality of outlets in the valve body;

wherein the sleeve is axially movable from a closed position, in which none of the outlets in the sleeve is aligned with an outlet in the body, to a plurality of valving positions including a first valving position in which the first outlet in the body is aligned with the corresponding outlet in the sleeve, a second valving position in which the second outlet in the body is aligned with the corresponding outlet in the sleeve, and a third valving position in which the third outlet in the body is aligned with the corresponding outlet in the sleeve; and

wherein the apparatus further comprises a push tube slidably supported in the housing and having first and second ends, the first end connectable to the elongate conduit for axial movement therewith when the lock assembly is in the unlocked position, the second end sized and positioned to engage the sleeve of the valve to cause axial movement thereof to move the sleeve from the closed position to the plurality of valving positions.

11. The apparatus of claim 10 wherein the apparatus further comprises a dump chamber adapted to receive fluid, wherein the back-up plate is further defined as movable in a second direction from the extended position to the retracted position, wherein the plurality of outlets in the valve body includes a fourth outlet fluidly connected to the second chamber of the cylinder of the setting/pack-off assembly to drive the movement of the piston in the second direction, wherein the valve body includes a second inlet fluidly connected to the first chamber of the cylinder of the setting/pack-off assembly, wherein the valve body includes a fifth outlet fluidly connected to the dump chamber, wherein the sleeve of the valve comprises a pass-through channel, and wherein

the sleeve is movable to a fourth valving position in which the fourth outlet in the body is aligned with the corresponding outlet in the sleeve to direct pressurized fluid into the second chamber of the back-up plate cylinder and in which the pass-through channel in the sleeve connects the second inlet of the valve body with the fifth outlet to permit fluid in the first chamber of the back-up plate cylinder to escape to the dump chamber.

12. The apparatus of claim 11 wherein the push tube defines a flow passage continuous with the elongate conduit, wherein the push tube is sealingly slidable on the support stem in the housing, wherein the support stem defines a flow passage continuous with the flow passage of the push tube, wherein the flow passage of the support stem is fluidly connected to the cylinder of the perforating assembly so that the flow path in the piercing member is continuous with the support stem.

13. The apparatus of claim 12 wherein the housing comprises a second flow path inside the housing above the valve body, wherein the housing comprises an outlet connecting the second flow path with the outside of the housing, wherein the push tube includes an opening positioned to be open to the second flow path in the housing when the sleeve is in the closed position and to be sealed by the support stem when the sleeve is in one of the plurality of valving positions, so that when the apparatus is connected to the elongate outlet and positioned in the tubular structure fluid can be passed through the elongate conduit, through the push tube, through the opening in the push tube into the second flow path in the housing, through the outlet in the housing to the outside of the housing.

14. The apparatus of claim 1 wherein the perforating assembly comprises a cylinder, wherein the piercing member is slidably supported in the cylinder, wherein the perforating assembly further comprises a first fluid-driven piston in the cylinder for driving the movement of the piercing member, wherein the apparatus further comprises a pressurized fluid reservoir fluidly connected to the cylinder so that when the reservoir is filled with pressured fluid the fluid can drive the piston, and wherein the control assembly comprises a valve adapted to control the flow of pressurized fluid from the reservoir to the cylinder.

15. The apparatus of claim 14 wherein the piercing member comprises a base, wherein the piercing member is movable from the second position to a third position in which the base is extendable through the perforation made by the piercing member to occlude the perforation, wherein first piston comprises a recess, wherein the perforating assembly further comprises a second fluid-driven piston slidably receivable in the recess for driving movement of the piercing member from the second position to the third position, wherein the recess is fluidly connected to the pressurized fluid reservoir so that when the reservoir is filled with pressured fluid the fluid can drive the movement of the second piston, and wherein the valve is adapted to control the flow of fluid from the reservoir to the recess.

16. The apparatus of claim 15 wherein the housing comprises a support stem and wherein the valve comprises:

a valve body having a tubular sidewall defining a longitudinal throughbore, wherein the sidewall comprises a first inlet fluidly

connected to the pressurized fluid reservoir, and a plurality of longitudinally spaced-apart outlets, one of the plurality of outlets fluidly connected to the cylinder of the perforating assembly to drive the movement of the first piston, another one of the plurality of outlets fluidly connected to the cylinder of the perforating assembly to drive the movement of the second piston;

a sleeve sealingly slidable inside the throughbore of the valve body;

wherein the sleeve comprises an outer wall, an inner wall, an annular space therebetween, a fluid inlet in the outer wall in fluid communication with the annular space, and a plurality of outlets in the outer wall in fluid communication with the annular space, each one of the plurality of outlets corresponding to a respective one of the plurality of outlets in the valve body;

wherein the sleeve is axially movable from a closed position, in which none of the outlets in the sleeve is aligned with an outlet in the body, to a plurality of valving positions including one valving position in which an outlet in the body is aligned with the corresponding outlet in the sleeve to fluidly connect the reservoir to the first piston of the perforating assembly, and another valving position in which another outlet in the body is aligned with the corresponding outlet in the sleeve to fluidly connect the reservoir to the second piston of the perforating assembly; and

wherein the apparatus further comprises a push tube slidably supported in the housing and having first and second ends, the second end sized and positioned to engage the sleeve of the valve to cause axial movement thereof.

17. The apparatus of claim 16 wherein the push tube defines a flow passage, wherein the push tube is sealingly slidable on the support stem of the housing, wherein the support stem defines a flow passage continuous with the flow passage of the push tube, wherein the flow passage of the support stem is fluidly connected to the cylinder of the perforating assembly so that the flow path in the piercing member is continuous with the support stem.

18. The apparatus of claim 17 wherein the housing comprises a second flow path inside the housing above the valve body, wherein the housing comprises an outlet connecting the second flow path with the outside of the housing, wherein the push tube includes an opening positioned to be open to the second flow path in the housing when the sleeve is in the closed position and to be sealed by the support stem when the sleeve is in one of the plurality of valving positions, so that when the apparatus is positioned in the tubular structure and the sleeve is in the closed position, fluid can be passed through the push tube, out the opening in the push tube into the second flow path in the housing, through the outlet in the housing to the outside of the housing, and so that when the sleeve is in one of the valving positions, fluid can be passed through the push tube, into the support stem through the perforating assembly and through piercing member.

19. The apparatus of claim 1 further comprising:

a setting/pack-off assembly adapted to secure the apparatus at the selected position in the tubular structure, the setting/pack-off assembly comprising:

a back-up plate sized to engage the tubular structure and movable in a first direction from a retracted position in which the back-up plate does not engage the tubular structure to an extended position in which the back-up plate engages the tubular structure;

a cylinder supported in the housing;

a fluid-driven piston sealingly slidable within the cylinder and dividing the cylinder into a first chamber and a second chamber;

a stem extending between the back-up plate and the piston; and

a pressurized fluid reservoir fluidly connected to the cylinder so that when the reservoir is filled with pressured fluid the fluid can drive the piston; and

wherein the control assembly comprises a valve adapted to control the flow of pressurized fluid from the reservoir to the cylinder, wherein the first chamber of the cylinder is fluidly connected to the pressurized fluid reservoir to push the piston in the first direction when the reservoir contains pressurized fluid, and wherein the valve controls the flow of fluid from the fluid reservoir to the cylinder of the setting/pack-off assembly.

20. The apparatus of claim 19 wherein the apparatus further comprises a dump chamber adapted to receive fluid, wherein the back-up plate is further defined as movable in a second direction from the extended position to the retracted position, wherein the second chamber of the cylinder is fluidly connected to the pressurized fluid reservoir to push the piston in the second direction when the reservoir contains pressurized fluid, wherein the first chamber of the cylinder is fluidly connected to the dump chamber, wherein the valve controls flow of fluid into the second chamber of the back-up plate cylinder to push the piston in the second direction and permits fluid in the first chamber of the back-up plate cylinder to escape to the dump chamber in response to movement of the piston in the second direction.

21. The apparatus of claim 1 wherein perforating assembly is fluid driven, wherein the apparatus further comprises a pressurized fluid reservoir, and wherein the control assembly comprises a valve for controlling fluid flow from the reservoir to the perforating assembly, the valve comprising:

a valve body having a tubular sidewall defining a longitudinal throughbore, wherein the sidewall comprises an inlet fluidly connected to the pressurized fluid reservoir and an outlet fluidly connected to the perforating assembly;

a sleeve sealingly slidable along the inside of the throughbore of the valve body;

wherein the sleeve comprises an outer wall, an inner wall, an annular space therebetween, a fluid inlet in the outer wall in fluid

communication with the annular space, and an outlet in the outer wall in fluid communication with the annular space;

wherein the sleeve is axially movable from a closed position, in which the outlet in the sleeve is not aligned with the outlet in the body, to a valving position in which the outlet in the body is aligned with the outlet in the sleeve; and

wherein the apparatus further comprises a push tube slidably supported in the housing and having first and second ends, the second end sized and positioned to engage the sleeve of the valve to cause axial movement thereof to move the sleeve from the closed position to the valving position.

22. A perforating system for perforating the casing in a subterranean well, the system comprising:

a rotatable and axially movable elongate conduit sized to be received in the casing, the conduit having an end extendable into the casing;

a perforating apparatus, the apparatus comprising:

a housing having a first end defining an inlet, the first end being connectable to the end of the conduit so that the conduit is continuous with the inlet of the housing, wherein the housing defines an operating fluid flow path beginning with the inlet;

wherein the housing being supportable at a selected position in the tubular structure;

a perforating assembly in the housing, the perforating assembly comprising a piercing member supported for movement from a first position within the housing to a second position in which a portion of the piercing member is extendable beyond the housing to perforate the well casing, wherein the piercing member comprises a fluid flow path;

wherein the perforating assembly defines a fluid flow path continuous with the operating fluid flow path through the housing and the fluid flow path in the piercing member so that when the piercing member is in the second position a continuous flow path is formed between the conduit and the

portion of the piercing member that this extendable through the well casing; and

a control assembly adapted to control movement of the piercing member.

23. The system of claim 22 wherein the perforating apparatus further comprises a releasable lock assembly operable by rotation of the elongate conduit between a locked, position in which the elongate conduit is fixed relative to the housing, and an unlocked position, in which the elongate conduit is axially movable relative to the housing.

24. The system of claim 22 further comprising a friction member on the housing sized to frictionally engage the well casing as the apparatus is pushed therethrough.

25. The system of claim 24 wherein the friction member is a bow-spring centralizer.

26. The system of claim 23 wherein the perforating assembly comprises a cylinder, wherein the piercing member is slidably supported in the cylinder, wherein the perforating assembly further comprises a first fluid-driven piston in the cylinder for driving the movement of the piercing member, wherein the apparatus further comprises a pressurized fluid reservoir fluidly connected to the cylinder so that when the reservoir is filled with pressured fluid the fluid can drive the piston, and wherein the control assembly comprises a valve adapted to control the flow of pressurized fluid from the reservoir to the cylinder.

27. The system of claim 26 wherein the perforating apparatus further comprises a setting/pack-off assembly adapted to secure the apparatus at the selected position in the well casing, the setting/pack-off assembly comprising:

a back-up plate sized to engage the well casing and movable in a first direction from a retracted position in which the back-up plate does not engage the well casing to an extended position in which the back-up plate engages the well casing;

a cylinder supported in the housing;

a fluid-driven piston sealingly slidable within the cylinder and dividing the cylinder into a first chamber and a second chamber;

a stem extending between the back-up plate and piston and;

wherein the first chamber of the cylinder is fluidly connected to the pressurized fluid reservoir to push the piston in the first direction when the reservoir contains pressurized fluid; and

wherein the valve controls the flow of fluid from the fluid reservoir to the cylinder of the setting/pack-off assembly.

28. The system of claim 27 wherein the housing of the perforating apparatus is cylindrical defining a side wall, wherein the piercing member extends radially through the side wall, wherein the back-up plate extends radially from the side wall of the housing and is positioned to move opposingly to the piercing member.

29. The system of claim 27 wherein the piercing member comprises a base and is movable from the second position to a third position in which the base is extendable through the perforation in the well casing to occlude the perforation, wherein

first piston of the perforating assembly comprises a recess, wherein the perforating assembly further comprises a second fluid-driven piston slidably receivable in the recess for driving movement of the piercing member from the second position to the third position, wherein the recess is fluidly connected to the pressurized fluid reservoir so that when the reservoir is filled with pressured fluid the fluid can drive the movement of the second piston, and wherein the valve is adapted to control the flow of fluid from the reservoir to the recess.

30. The system of claim 29 wherein the valve comprises:

a valve body having a tubular sidewall defining a longitudinal throughbore, wherein the sidewall comprises a first inlet fluidly connected to the pressurized fluid reservoir, and a plurality of longitudinally spaced-apart outlets, a first one of the plurality of outlets fluidly connected to the first chamber of the cylinder of the setting/pack-off assembly to drive the piston in the first direction, a second one of the plurality of outlets fluidly connected to the cylinder of the perforating assembly to drive the movement of the first piston, a third one of the plurality of outlets fluidly connected to the cylinder of the perforating assembly to drive the movement of the second piston;

a sleeve sealingly slidable along of inside of the throughbore of the valve body;

wherein the sleeve comprises an outer wall, an inner wall, an annular space therebetween, a fluid inlet in the outer wall in fluid

communication with the annular space, and a plurality of outlets in the outer wall in fluid communication with the annular space, each one of the plurality of outlets corresponding to a respective one of the plurality of outlets in the valve body;

wherein the sleeve is axially movable from a closed position, in which none of the outlets in the sleeve is aligned with an outlet in the body, to a plurality of valving positions including a first valving position in which the first outlet in the body is aligned with the corresponding outlet in the sleeve, a second valving position in which the second outlet in the body is aligned with the corresponding outlet in the sleeve, and a third valving position in which the third outlet in the body is aligned with the corresponding outlet in the sleeve; and

wherein the perforating apparatus further comprises a push tube slidably supported in the housing and having first and second ends, the first end connectable to the elongate conduit for axial movement therewith when the lock assembly is in the unlocked position, the second end sized and positioned to engage the sleeve of the valve to cause axial movement thereof to move the sleeve from the closed position to the plurality of valving positions.

31. The system of claim 30 wherein the perforating apparatus further comprises a dump chamber adapted to receive fluid, wherein the back-up plate is further defined as movable in a second direction from the extended position to the retracted position, wherein the plurality of outlets in the valve body includes a fourth outlet fluidly

connected to the second chamber of the cylinder of the setting/pack-off assembly to drive the movement of the piston in the second direction, wherein the valve body includes a second inlet fluidly connected to the first chamber of the cylinder of the setting/pack-off assembly, wherein the valve body includes a fifth outlet fluidly connected to the dump chamber, wherein the sleeve of the valve comprises a pass-through channel, and wherein the sleeve is movable to a fourth valving position in which the fourth outlet in the body is aligned with the corresponding outlet in the sleeve to direct pressurized fluid into the second chamber of the back-up plate cylinder and in which the pass-through channel in the sleeve connects the second inlet of the valve body with the fifth outlet to permit fluid in the first chamber of the back-up plate cylinder to escape to the dump chamber.

32. The system of claim 31 wherein the housing comprises a support stem fixed relative to the housing and receivable inside the sleeve of the valve sleeve, wherein the push tube defines a flow passage continuous with the elongate conduit, wherein the push tube is sealingly slidable on the support stem, wherein the support stem defines a flow passage continuous with the flow passage of the push tube, wherein the flow passage of the support stem is fluidly connected to the cylinder of the perforating assembly so that the flow path in the piercing member is continuous with the support stem.

33. The system of claim 32 wherein the housing comprises a second flow path inside the housing above the valve body, wherein the housing comprises an outlet connecting the second flow path with the outside of the housing, wherein the push tube includes an opening positioned to be open to the second flow path in the housing when the sleeve is in the closed position and to be sealed by the support stem when the

sleeve is in one of the plurality of valving positions, so that when the apparatus is connected to the elongate outlet and positioned in the tubular structure fluid can be passed through the elongate conduit, through the push tube, through the opening in the push tube into the second flow path in the housing, through the outlet in the housing to the outside of the housing.

34. The system of claim 22 wherein the perforating assembly comprises a cylinder, wherein the piercing member is slidably supported in the cylinder, wherein the perforating assembly further comprises a first fluid-driven piston in the cylinder for driving the movement of the piercing member, wherein the perforating apparatus further comprises a pressurized fluid reservoir fluidly connected to the cylinder so that when the reservoir is filled with pressured fluid the fluid can drive the piston, and wherein the control assembly comprises a valve adapted to control the flow of pressurized fluid from the reservoir to the cylinder.

35. The system of claim 34 wherein the piercing member comprises a base, wherein the piercing member is movable from the second position to a third position in which the base is extendable through the perforation to occlude the perforation, wherein first piston comprises a recess, wherein the perforating assembly further comprises a second fluid-driven piston slidably receivable in the recess for driving movement of the piercing member from the second position to the third position, wherein the recess is fluidly connected to the pressurized fluid reservoir so that when the reservoir is filled with pressured fluid the fluid can drive the movement of the second piston, and wherein the valve is adapted to control the flow of fluid from the reservoir to the recess.

36. The system of claim 35 wherein the valve comprises:

a valve body having a tubular sidewall defining a longitudinal throughbore, wherein the sidewall comprises a first inlet fluidly connected to the pressurized fluid reservoir, and a plurality of longitudinally spaced-apart outlets, one of the plurality of outlets fluidly connected to the cylinder of the perforating assembly to drive the movement of the first piston, another one of the plurality of outlets fluidly connected to the cylinder of the perforating assembly to drive the movement of the second piston;

a sleeve sealingly slidable inside the throughbore of the valve body;

wherein the sleeve comprises an outer wall, an inner wall, an annular space therebetween, a fluid inlet in the outer wall in fluid communication with the annular space, and a plurality of outlets in the outer wall in fluid communication with the annular space, each one of the plurality of outlets corresponding to a respective one of the plurality of outlets in the valve body;

wherein the sleeve is axially movable from a closed position, in which none of the outlets in the sleeve is aligned with an outlet in the body, to a plurality of valving positions including one valving position in which an outlet in the body is aligned with the corresponding outlet in the sleeve to fluidly connect the reservoir to the first piston of the perforating assembly, and another valving position in which another outlet in the body is aligned with the

corresponding outlet in the sleeve to fluidly connect the reservoir to the second piston of the perforating assembly; and

wherein the perforating apparatus further comprises a push tube slidably supported in the housing and having first and second ends, the second end sized and positioned to engage the sleeve of the valve to cause axial movement thereof.

37. The system of claim 36 wherein apparatus further comprises a support stem fixed relative to the housing, wherein the push tube defines a flow passage, wherein the push tube is sealingly slidable on the support stem, wherein the support stem defines a flow passage continuous with the flow passage of the push tube, wherein the flow passage of the support stem is fluidly connected to the cylinder of the perforating assembly so that the flow path in the piercing member is continuous with the support stem.

38. The system of claim 37 wherein the housing comprises a second flow path inside the housing above the valve body, wherein the housing comprises an outlet connecting the second flow path with the outside of the housing, wherein the push tube includes an opening positioned to be open to the second flow path in the housing when the sleeve is in the closed position and to be sealed by the support stem when the sleeve is in one of the plurality of valving positions, so that when the apparatus is positioned in the well casing and the sleeve is in the closed position, fluid can be passed through the push tube, out the opening in the push tube into the second flow path in the housing, through the outlet in the housing to the outside of the housing and up through the elongate conduit, and so that when the sleeve is in one of the valving positions, fluid

can be passed through the push tube, into the stem through the perforating assembly and through piercing member through perforation in the well casing.

39. The system of claim 22 wherein the perforating apparatus further comprises:

a setting/pack-off assembly adapted to secure the apparatus at the selected position in the well casing, the setting/pack-off assembly comprising:

a back-up plate sized to engage the well casing and movable in a first direction from a retracted position in which the back-up plate does not engage the well casing to an extended position in which the back-up plate engages the well casing;

a cylinder supported in the housing;

a fluid-driven piston sealingly slidable within the cylinder and dividing the cylinder into a first chamber and a second chamber;

a stem extending between the back-up plate and the piston; and

a pressurized fluid reservoir fluidly connected to the cylinder so that when the reservoir is filled with pressured fluid the fluid can drive the piston; and

wherein the control assembly comprises a valve adapted to control the flow of pressurized fluid from the reservoir to the cylinder, wherein the first chamber of the cylinder is fluidly connected to the pressurized fluid reservoir to push the piston in the

first direction when the reservoir contains pressurized fluid, and wherein the valve controls the flow of fluid from the fluid reservoir to the cylinder of the setting/pack-off assembly.

40. The system of claim 39 wherein the perforating apparatus further comprises a dump chamber adapted to receive fluid, wherein the back-up plate is further defined as movable in a second direction from the extended position to the retracted position, wherein the second chamber of the cylinder is fluidly connected to the pressurized fluid reservoir to push the piston in the second direction when the reservoir contains pressurized fluid, wherein the first chamber of the cylinder is fluidly connected to the dump chamber, wherein the valve controls flow of fluid into the second chamber of the back-up plate cylinder to push the piston in the second direction and permits fluid in the first chamber of the back-up plate cylinder to escape to the dump chamber in response to movement of the piston in the second direction.

41. The system of claim 22 wherein perforating assembly is fluid driven, wherein the perforating apparatus further comprises a pressurized fluid reservoir, and wherein the control assembly comprises a valve for controlling fluid flow from the reservoir to the perforating assembly, the valve comprising:

a valve body having a tubular sidewall defining a longitudinal throughbore, wherein the sidewall comprises an inlet fluidly connected to the pressurized fluid reservoir and an outlet fluidly connected to the perforating assembly;

a sleeve sealingly slidable inside the throughbore of the valve body;

wherein the sleeve comprises an outer wall, an inner wall, an annular space therebetween, a fluid inlet in the outer wall in fluid communication with the annular space, and an outlet in the outer wall in fluid communication with the annular space;

wherein the sleeve is axially movable from a closed position, in which the outlet in the sleeve is not aligned with the outlet in the body, to a valving position in which the outlet in the body is aligned with the outlet in the sleeve; and

wherein the perforating apparatus further comprises a push tube slidably supported in the housing and having first and second ends, the second end sized and positioned to engage the sleeve of the valve to cause axial movement thereof to move the sleeve from the closed position to the valving position.

42. A valve for directing fluid from a source of pressurized fluid to one of a plurality of fluid-operated devices, the valve comprising:

a valve body having a tubular sidewall defining a longitudinal throughbore, wherein the sidewall comprises a first inlet fluidly connectable to the fluid source, and a plurality of longitudinally spaced-apart outlets, each of the plurality of outlets connectable to a different one of the fluid-operated devices;

a sleeve sealingly slidable inside the throughbore of the valve body;

wherein the sleeve comprises an outer wall, an inner wall, an annular space therebetween, a fluid inlet in the outer wall in fluid communication with the annular space, and a plurality of outlets in the outer wall in fluid communication with the annular space, each one of the plurality of outlets corresponding to a respective one of the plurality of outlets in the valve body;

wherein the sleeve is axially movable from a closed position, in which none of the outlets in the sleeve is aligned with its corresponding outlet in the body, to a plurality of valving positions in which the inlet in the sleeve is aligned with the inlet in the valve body and in which one of the plurality of outlets in the valve body is aligned with the corresponding outlet in the sleeve, so that in each of the valving positions, fluid from fluid source is directed to the respective one of the fluid-operated devices.

43. The valve of claim 42 wherein the stem is hollow.

44. A method for establishing a fluid flow path between one end of a tubular structure and a selected area outside the tubular structure a distance from the end, the method comprising:

perforating the tubular structure at a position near the selected area; and

flowing flowable material between the end of the tubular structure and the selected area outside the tubular structure without leaving a significant amount of the fluid inside the tubular structure.

45. The method of claim 44 wherein the tubular structure is the casing in a subterranean well.

46. The method of claim 44 wherein the flowing step comprises injecting the flowable material through the perforation into the selected area.

47. The method of claim 46 further comprising the step of plugging the perforation after the flowable material has been injected.

48. An apparatus for perforating a tubular structure, the apparatus comprising:

a housing having an inlet and an outlet;

a fluid-driven piercing member supported for movement from a first position within the housing to a second position in which a portion of the piercing member is extendable through the tubular structure, wherein the piercing member comprises a fluid flow path;

wherein the housing defines an operating fluid flow path beginning with the inlet and connectable alternately with the fluid flow path in the piercing member and the outlet of the housing;

a pressurized fluid reservoir fluidly connected to the fluid driven piercing member;

a first valve adapted to control flow of fluid between the high pressure fluid reservoir and the piercing member to drive the movement of the piercing member from the first position to the second position; and

a second valve adapted to control flow of fluid between the operating flow path in the housing and to either of the flow path in the piercing member and the outlet of the housing.

49. The apparatus of claim 48 wherein the inlet of the apparatus is connectable to an elongate conduit extendable through the tubular structure and wherein the first valve is operable by axial movement of the conduit when it is connected to the apparatus.

50. The apparatus of claim 49 wherein the second valve is operable by axial movement of the conduit when it is connected to the apparatus.

51. The apparatus of claim 48 wherein the inlet of the apparatus is connectable to an elongate conduit extendable through the tubular structure and wherein the apparatus further comprises a releasable lock assembly operable by rotation of the elongate conduit between a locked, position in which the elongate conduit is fixed relative to the housing, and an unlocked position, in which the elongate conduit is axially movable relative to the housing.

52. The apparatus of claim 51 wherein the first valve is operable by axial movement of the conduit when it is connected to the apparatus.

53. The apparatus of claim 51 wherein the second valve is operable by axial movement of the conduit when it is connected to the apparatus.

54. The apparatus of claim 53 wherein the first valve comprises:

a valve body having a tubular sidewall defining a longitudinal throughbore, wherein the sidewall comprises a first inlet fluidly connected to the pressurized fluid reservoir, and an outlet fluidly connected to the piercing member;

a stem supported non-movingly and longitudinally within the throughbore of the valve body;

a sleeve sealingly slidable along outside of the stem and inside the throughbore of the valve body;

wherein the sleeve comprises an outer wall, an inner wall, an annular space therebetween, a fluid inlet in the outer wall in fluid communication with the annular space, and an outlet in the outer wall in fluid communication with the annular space;

wherein the sleeve is axially movable from a closed position, in which the outlet in the sleeve is not aligned with the outlet in the body, to a valving position in which the outlet in the body is aligned with the outlet in the sleeve, and

wherein the apparatus further comprises a push tube slidably supported in the housing and having first and second ends, the first end connectable to the elongate conduit for axial movement therewith when the lock assembly is in the unlocked position, the second end sized and positioned to engage the sleeve of the valve to cause axial movement thereof to move the sleeve from the closed position to the valving position.

55. The apparatus of claim 54 wherein the housing comprises a second flow path inside the housing above the valve body, wherein the outlet in the housing connects the second flow path with the outside of the housing, wherein the second valve comprises an opening in the push tube positioned to be open to the second flow path in the housing when the sleeve is in the closed position and to be sealed by the stem when the sleeve is in the valving position, so that when the apparatus is connected to the elongate outlet and positioned in the tubular structure fluid can be passed through the elongate conduit alternately out the outlet in the housing to the outside of the housing when the sleeve is in the closed position or through the piercing member out the perforation when the sleeve is in the valving position.

56. An apparatus for perforating a tubular structure, the apparatus comprising:

a housing;

a piercing member supported in the housing for movement from a first position within the housing to a second position in which a portion of the piercing member is extendable through the tubular structure;

a fluid driven setting/pack-off assembly adapted to secure the apparatus temporarily at a selected position in the tubular structure, the setting/pack-off assembly comprising:

a back-up plate sized to engage the tubular structure and movable in a first direction from a retracted position in which the back-up plate does not engage the tubular structure to an extended position in which the back-up plate engages the tubular structure, and in a second direction from the extended position to the retracted position;

a pressurized fluid reservoir fluidly connected to the setting/pack-off assembly; and

a valve adapted to control the flow of fluid from the fluid reservoir to the setting/pack-off assembly.

57. The apparatus of claim 56 wherein the setting/pack-off assembly further comprises:

a cylinder supported in the housing;

a fluid-driven piston sealingly slidable within the cylinder and dividing the cylinder into a first chamber and a second chamber;

a stem extending between the back-up plate and the piston; and

wherein the apparatus further comprises a dump chamber adapted to receive fluid, wherein the first chamber of the cylinder of the setting/pack-off assembly is fluidly connected to the pressurized fluid reservoir to drive movement of the back-up plate in the first direction, wherein the second chamber of the cylinder of the setting/pack-off assembly is fluidly connected to the pressurized fluid reservoir to drive movement of the back-up plate in the second direction, and wherein the second chamber is fluidly connected to the dump chamber to receive fluid in response to movement of the back-up plate in the second direction, wherein the valve controls flow of fluid from the pressurized fluid reservoir to the first and second chambers and from the second chamber to the dump chamber.